5 Technology

Techne is the Greek root of our modern words technical and technology but, in contrast to contemporary meanings, ancient Greeks used this term to refer to the skill of the artist. Of course en route from the artists of ancient Greece to our times, the meaning of *techne* was shaped, in turn, by artisans during the Middle Ages, craft workers in the pre-industrial era, and industrial age production engineers.

At each of these stages of development *techne*'s early association with art became more obscured by modern tendencies to objectify, for example by equating technology with the tangible tools, equipment, machines, and procedures by which work is accomplished. Recent shifts toward post-industrial mindsets, however, move industrial understandings of technology back in the direction of *techne*'s original meaning by re-invoking its relationship to power/knowledge or else to craftsmanship and artistry. For example, Nissan fused its industrial technology with the post-industrial by giving marketing a key role in product design to ensure that every aspect of the way it builds cars is artfully infused with the spirit of its brand to 'Shift_ thinking.'[1]

In contrast to the tools and techniques orientation the modern perspective favors, the symbolic study of technology emphasizes, not what technology produces, but how technology itself is produced by social construction and enactment. From this perspective technology is both an outcome of social processes and a process of ongoing learning and design activity. It often relies upon the historical or ethnographic study of technology under construction and technology-in-use.

Because technological design builds behavioral demands directly into production systems, managers and designers can magnify their control over workers through the production technologies they choose. For this reason many critical postmodernists believe technologies impose discipline on those who use them by providing the means to monitor and control behavior. Concerns about privacy and security create images of the evil purposes to which technology can be put, but technology also unleashes powerful forces to combat these negative effects. For example, social media enables people to organize, lobby, and take collective action based on their own interests rather than the interests of those who claim authority over them. The futuristic thinking of other postmodernists sees technology fusing with organization to produce 'cyborganizations.'

Each of these ideas will be examined as we follow the development of the concept of technology within each of the three perspectives, starting with the modern.

Modernist definitions of technology and three typologies

Automotive firms design and manufacture cars and trucks, hospitals care for sick people, and universities educate citizens. Just so, modern organization theorists believe, the purpose an organization fulfills intimately links its technology to its environment (see Figure 5.1). Every organization employs a specific **technology**, or interrelated group of technologies, defined as the means it uses to transform inputs into products or services.

The concept of technology can be applied to any analytical level you choose, from organization to units, jobs, and tasks. At the organization level technology typically refers to the **core technology** that secures an uninterrupted flow of resources that sustains the organization. If an organization employs more than one core technology, as happens in conglomerates like GE, Charoen Pokphand, or Tata that combine unrelated businesses, you will need to perform separate analyses on each one and then analyze the relationships between them (or lack thereof).

At the unit level of analysis you can identify different technologies operating within any one organization that support the core, as do those of purchasing, marketing, accounting, personnel, finance, and sales functions. Unit level technologies of course can be broken down still further into technologies operating at the task level, such as those for maintaining machinery, assembling products, handling complaints, planning budgets, purchasing supplies, or producing reports, to name only a few possibilities.

You might describe a university's core technology as research and education, or simply knowledge production. A richer image of this technology would be formed by separately analyzing how knowledge production is accomplished across the various departments and in each classroom, research laboratory, and administrative office that constitutes the university. The technologies of all these units could be further analyzed at the task level by focusing, for example, on the technologies of teaching (e.g., techniques of classroom engagement and examination), research (e.g., research design and data collection), and administration (e.g., student recruitment and matriculation). Of course any of these could be analytically broken down and examined in even greater detail.

Because many technologies operate simultaneously at all levels within every organization, the term technology can generate confusion if you are not careful to define your level

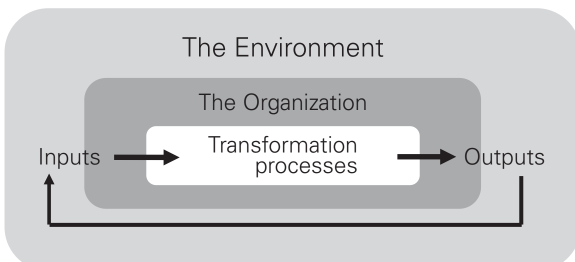

Figure 5.1 The organization as a technical system for transforming inputs into outputs

The technology of the organization is connected to the environment by its need for resource inputs and a market for the product and/or service that forms its output. The uninterrupted consumption of its output stream, shown by the arrow from outputs back to inputs in this modernist model, ensures new resource inputs will be provided to the organization.

of analysis. You also need to be aware of differences between service and manufacturing technologies. The addition of services to the thinking of organization theorists interested in technology highlights three distinctive characteristics of **services**: services are (1) consumed at the same time they are produced, (2) intangible, and (3) cannot be stored in inventory.

Consider the example of a news organization whose service involves providing customers with access to information. Because information only becomes news when it is communicated, news is consumed at the moment that it is produced. It is intangible in the sense that it occurs in the act of communication rather than in the form a specific act of communication takes (e.g., newspaper, broadcast). Because what is news today will not be news tomorrow, news cannot be stored.

Contrast the news with an automobile. Automobiles are not consumed as they are produced, but rather can be stored for months or years without losing too much of their value—they can be sold and resold years after their date of manufacture. Some models even gain value over time. Nonetheless, many aspects of the product of an automobile manufacturing technology are similar to those of a service technology. For example, the value of the style and design of most automobiles dissipates rapidly with the introduction of new models.

The distinction between service and manufacturing technologies can be difficult to maintain beyond a superficial categorization of particular types of businesses (e.g., by industrial codes that separate manufacturing and service organizations into different categories). When you undertake a more detailed analysis of an organization's technology you will notice that the outputs of most technologies have both service and manufacturing characteristics. For example, the warranty that accompanies newly manufactured automobiles is a promise of service that attaches to many automotive products, making them combinations of products and services. Or consider how banks often refer to the services they offer as products. Treating a service like a product encourages attending to packaging and other concerns associated with manufactured goods. For their part, numerous manufacturing firms have become obsessed with customer service.

The cross-fertilization of ideas between the domains of service and manufacturing technologies indicates that the distinction so often made between them is not a clean one. Nonetheless, the distinction contributed much to the early development of modernist theories of technology.

Types of technology

Early modernists focused on comparing the core technologies of manufacturing organizations. As knowledge about technology developed beyond industrial applications, modern organization theorists extended and refined their typologies to encompass first service and then task level technologies. Developing ways of measuring and comparing technology types and levels of analysis contributed new variables to contingency theory to reveal that the performance of a given social structure is not just contingent on the environment, but on technology as well. Joan Woodward, James Thompson, and Charles Perrow are the modernists chiefly responsible for adding the concept of technology to organization theory.

Woodward's typology

Although Joan Woodward, a British sociologist, was among the first organization theorists to draw attention to the importance of technology, her initial research question did not concern technology at all. At the time Woodward designed her study the legacy of the classical management school dominated organization theory. Differences of opinion over which of the proposed ways of organizing was best captured the imaginations of researchers and, in this context, Woodward decided to design what for that time was a large sample scientific study to find out once and for all which organizational arrangements produce the highest levels of performance.

Woodward surveyed 100 manufacturing organizations operating in the vicinity of South Essex, England. Her survey measured relative levels of performance (above average, average, and below average for their industry), average span of control, number of management levels, degree of centralization in decision-making practices, and management style. Woodward expected to find that one constellation of these classical management variables consistently related to high levels of performance, thus she was quite surprised when her analysis revealed no significant relationships.

Such an unexpected result could not be presented without explanation so Woodward sought an answer by trying different approaches to her data. At one point she grouped companies according to their level of technical complexity, which she defined as the degree of mechanization in the core manufacturing process. This move revealed the pattern that made Woodward famous. Her analysis showed that structure was related to performance after all, but only when the type of core technology used by the organization was taken into account as a key contingency. That is, the best structure for an organization (i.e., one associated with high performance) depended upon the core technology employed.

Woodward's scale of technological complexity, which she developed to describe the technologies used in her sample of organizations, is shown in Figure 5.2. On the left side of the figure you will see how her scale was broken up into three parts to provide a simple typology consisting of (1) unit or small batch technologies, (2) large batch or mass production, and (3) continuous processing.

Unit and small batch technologies produce one item or unit at a time; or a few items all at once. A small amount of product, whether unit-by-unit or in a batch, is produced from start to finish and then the process begins again. Custom-made clothing, such as a tailored suit or theatrical costume, is usually the product of unit production technology. Other products typically produced in this way include original works of art, designer glassware, commercial or custom building projects, and engineering prototypes. Wine is produced using small batch technology—a quantity of wine is produced in one lot. Small batch technologies are also found in traditional bakeries and most college classrooms. In both unit and small batch technologies workers typically participate in the whole production process start to finish and so have a fairly complete understanding of the technology being used. Woodward's study showed that organizations that use unit and small batch technologies are more successful when they have smaller spans of control, fewer levels of management, and when they practice decentralized decision making—characteristics associated with organic organizational forms.

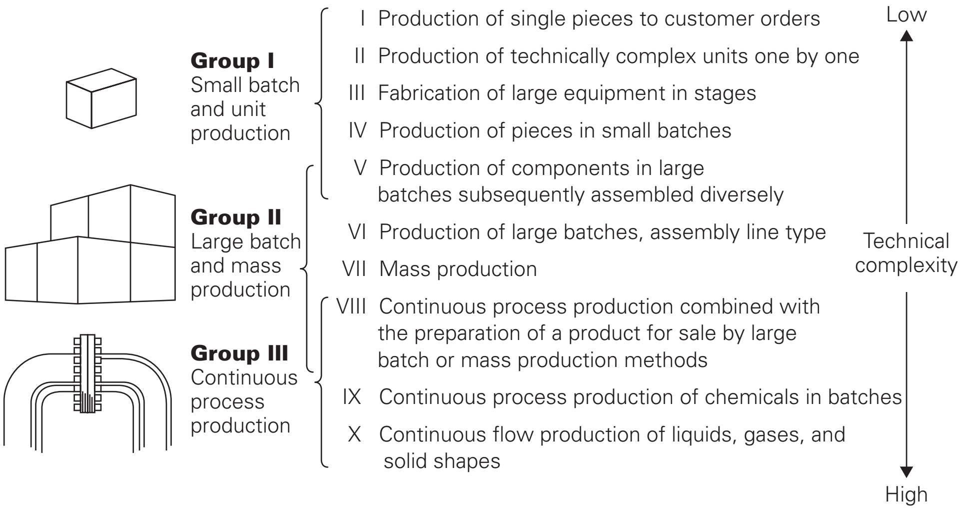

Figure 5.2 Woodward's original typology showing how she arrived at the technical complexity scale

Source: Woodward (1958). Crown copyright is reproduced with the permission of the Controller of HMSO.

Large batch or mass production technologies produce great quantities of identical products using highly routinized and often mechanized procedures. These technologies involve breaking the total production process into many discrete steps that can be performed either by human hands or machines. An automobile assembly line is an example of mass production technology while steel production is an example of large batch technology. In large batch and mass production technologies workers repetitively perform a subset of the tasks involved in producing output. For instance, mass production workers are often physically located in positions adjacent to others whose activities are sequentially related to their own—the person on one side of them performs the task that precedes theirs, and the person on their other side performs the task that follows theirs. Woodward's study showed that organizations using large batch and mass production technologies are more successful when their managers have larger spans of control and when they practice centralized decision making—characteristics associated with mechanistic forms of organizing.

Whereas mass production is a series of discrete tasks performed sequentially, **continuous processing** is a series of non-discrete transformations occurring in a sequence. Consider the examples of oil refining and waste treatment. In these cases, raw material (crude oil, raw sewage) is fed into one end of the process and, as it flows continuously through the system, contaminants and other unwanted substances are removed until the desired degree of refinement is reached (refined oil, treated sewage). In continuous processing, humans tend equipment that affects the transformation automatically, whereas in mass production direct human intervention is involved in at least some parts of the production process. Woodward's study showed that the patterns of organizing in successful continuous processing organizations were similar to those for unit and small batch technologies in that they had smaller spans of control and decentralized decision making; however, they required more levels of management than either small batch or mass production technologies due to the greater technical complexity of the manufacturing process.

In general, Woodward found that the highest levels of performance among her firms were achieved when mass production technologies were combined with mechanistic organizational forms, and when small batch or continuous processing technologies were combined with organic forms (these and other findings from her study are summarized in Table 5.1). However, subsequent studies showed that Woodward's typology was limited in two ways. First, her study examined mainly small and medium-sized organizations and the moderating relationship she found between technology and the structure–performance link proved to be less important when organizational structures are large and therefore more complex. Second, Woodward had ignored the technologies used to provide services, a limitation Thompson sought to overcome.

Thompson's typology

In the late 1960s American sociologist James Thompson stretched Woodward's typology to include both manufacturing and service sector technologies.[2] Thompson's theory rested on distinguishing between long-linked, mediating, and intensive technologies.

Long-linked technologies encapsulate both the mass production and continuous processing categories Woodward defined. Thus automobile assembly lines as well as technologies for producing chemicals and generating electrical power fit the category of long-linked technology. Thompson used the descriptive term long-linked because all technologies of this type involve linear transformation processes in which inputs enter at one end of a long series of sequential steps from which products emerge at the other end.

Table 5.1 Findings from Woodward's study linking technology to social structure

Structural dimension	Technology		
	Unit production	*Mass production*	*Continuous process*
Levels of management	3	4	6
Span of control	23	48	15
Ratio of direct to indirect labor	9:1	4:1	1:1
Administrative ratio	low	medium	high
Formalization (written communication)	low	high	low
Centralization	low	high	low
Verbal communication	high	low	high
Skill level of workers	high	low	high
Overall structure	organic	mechanistic	organic

Source: Woodward (1965). By permission of Oxford University Press.

Mediating technologies serve clients or customers by bringing them together in an exchange or other transaction. Banks, brokerage firms, and insurance companies all operate using mediating technology that links the participants by helping them locate one another and conduct their transactions, often without ever having to physically meet. For example, banks use mediating technology to bring together savers who want to invest money and borrowers who want to take out loans. Banking technology mediates between savers and borrowers by providing a location for both types of customers, and by providing standardized procedures to facilitate their mutual benefit, in this case, interest payments for savers and funds for borrowers. eBay links sellers and buyers through mediating technology providing software applications often involving further mediation from a financial services provider such as PayPal or a credit card company.

Intensive technology occurs in hospital emergency rooms, research laboratories, and in project organizations such as those typical within the construction industry and engineering firms. Intensive technologies require coordinating the specialized abilities of two or more experts in the transformation of a usually unique input into a customized output. Each use of intensive technology requires on-the-spot development and application of specialized knowledge to new problems or unique circumstances.

Thompson's typology was grounded in the open systems model of organization according to which a core technology is open to its environment on both the input and output sides (see Figure 5.1). This model drew Thompson's attention to the inputs to the technical process and the outputs it produced. He observed that some technologies use highly standardized inputs and outputs (e.g., traditional mass production automobile manufacturing assembles nearly identical parts into nearly identical automobiles), while in others unstandardized inputs are used to produce unstandardized outputs (e.g., hospital emergency rooms transform diseased or injured patients into stabilized patients for discharge or ready to be input into other hospital services).

In addition to input and output standardization, Thompson also recognized that technologies differed depending upon their transformation processes. He characterized some technologies as standardized in their processing of inputs into outputs (e.g., automobile assembly workers perform the same tasks repeatedly), and others as having little process standardization (e.g., emergency room personnel respond to the unique needs of each patient as they come through the door).

Thompson's theory can be summarized using a two-by-two matrix classifying core technologies according to their standardization of inputs/outputs and their standardization of transformation process (see Figure 5.3). The four cells of the matrix represent Thompson's three types of organizational technologies, plus one extra: (1) standardized inputs/outputs with standardized transformation processes describe long-linked technologies, (2) unstandardized inputs/outputs with standardized transformation processes describe mediating technologies, (3) unstandardized inputs/outputs with unstandardized transformation processes describe intensive technologies, and (4) standardized inputs/outputs with unstandardized transformation processes.

It is interesting to speculate about why Thompson ignored the fourth cell of this matrix—standardized inputs/outputs with unstandardized transformation processes. The absence of a description of this category is probably due to the enormous inefficiency Thompson would have associated with such a technology. Imagine producing a standard product with

Inputs/Outputs	Transformation processes: *standardized*	Transformation processes: *non-standardized*
standardized	Long-linked	?
non-standardized	Mediating	Intensive

Figure 5.3 Two-by-two matrix showing Thompson's typology of technologies

Source: Based on Thompson (1967).

standard inputs, and doing so in a different way every time. While such technologies do exist (e.g., building design prototypes for manufacturing processes, brainstorming innovative ideas), Thompson, a modernist who was obsessed with applying norms of rationality, may have deliberately ignored this type of technology, thereby making way for Perrow to take another stab at creating an all-encompassing typology.

Perrow's typology

Whereas Woodward's and Thompson's typologies only considered core technology, American sociologist Charles Perrow dropped from the organizational to the task level of analysis to develop his framework.[3] Perrow began by defining the variability and analyzability of tasks as the means of differentiating technologies (see Figure 5.4).

Task variability refers to the number of exceptions to standard procedures encountered in the application of a given technology. **Task analyzability** is the extent to which, when an exception is encountered, there are known methods for dealing with it. Although Perrow defined task variability and task analyzability at the level of tasks, these two variables have been used to characterize technologies at the unit and organizational levels of analysis. Arraying task variability and task analyzability in a two-by-two matrix produces four technology types Perrow named routine, craft, engineering, and non-routine.

Routine technologies are characterized by low task variability and high task analyzability. The traditional automobile assembly line that illustrates Thompson's long-linked technology and Woodward's mass production category also fit Perrow's routine technology category. Clerical work is another example, this one representing a service technology. Filing clerks, for instance, encounter few exceptions to their standardized work practices and when they do there is almost always a known method of resolution, such as hierarchical referral (i.e., ask the boss).

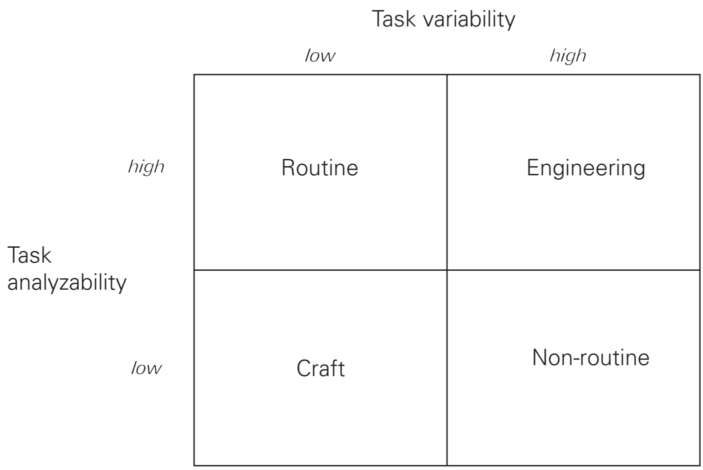

Figure 5.4 Two-by-two matrix showing Perrow's typology of technologies

Source: Based on Perrow (1967).

Craft technology describes conditions of low task variability and low task analyzability. Construction work is a craft technology. The construction worker encounters few exceptions to standard procedures but when exceptions do arise, such as mistakes in planning or unavailable materials, a way of dealing with them must be invented. Most forms of artistic production provide other examples of craft technology, as does locating water for drilling wells. In craft technologies intuition and experience become extremely important, as happens when standard geological solutions to finding water fail. Although standard procedures usually work in craft technologies, when exceptions occur (e.g., an artist runs out of canvas or paint, no water is found using scientific prediction), there are few known solutions upon which workers can rely. In these conditions experience, intuition, and improvisation play important roles.

Engineering technologies occur where high task variability combines with high task analyzability. The technologies of laboratory technicians, executive secretaries, accountants, and most engineers fit the engineering category. In engineering technology many exceptions to standard practices arise but employees possess the knowledge needed to solve these problems. Often the knowledge required by engineering technologies comes from advanced and highly specialized training, thus the presence of a great deal of professional work usually indicates an engineering technology in use.

Perrow labeled as **non-routine technology** those characterized by high task variability and low task analyzability. These conditions occur, for instance, in research and development departments, aerospace engineering, and in design and prototype laboratories. Perrow's non-routine category overlaps Woodward's unit and small batch technologies and has commonalities with Thompson's intensive category as well as his missing category of standardized input/outputs and unstandardized transformation processes. The high number of problems encountered in non-routine technologies, and the lack of known methods for solving them, place employees using these technologies in a more or less constant state of uncertainty.

Using the three typologies

Even though the three typologies discussed so far overlap, you should still begin a modernist technology analysis by applying all three in order to maximize the information available to you. Using all three will force you to consider the six dimensions that collectively underpin these types: technical complexity, routineness of work, standardization of inputs/outputs, standardization of transformation processes, task variability, and task analyzability. Although you may ultimately conclude you do not need all of these dimensions to adequately describe the technology you are studying, until you try them out on your organization you will not know which are most helpful. Many times I have been surprised by the insight provided when I applied a theory I did not initially believe would help me.

To see how to apply the typologies, consider a company that manufactures buses. A chassis is brought in at one end of the factory and moves down the assembly line where axels, an engine, the body, interior trim, and so on are added. Your initial assessment might be that the core technology at the organizational level of analysis is *long-linked* (Thompson). You can see that it is not *large batch* (Woodward), because even though there are 50 buses at various stages of completion on the assembly line—ten are for one customer, five for another customer, two for another—each order has different requirements for heating, air conditioning, internal features, and external trim, making it a *small batch* technology (Woodward).

Closer analysis of bus manufacturing at the unit level reveals that the Chassis and Suspension Department can be characterized by *routine* technology (Perrow) because task variability is low (the only variation is the choice of two chassis lengths) and task analyzability is high (there are standardized methods for positioning and bolting the suspension on the chassis). The Internal Trim Department, however, is characterized by *engineering* technology because task variability is high (different customers want different seating configurations, heaters, handrails, doors, lights, decals, etc., situated in different places) as is task analyzability (there are known procedures and methods for dealing with these differences).

The bus-manufacturing example highlights the complexity of analyzing the technology of an organization and the danger of ignoring one or more levels of analysis. By focusing only on core technology at the organizational level you lose the interesting details of technological diversity that emerge in analyses conducted at the unit and task levels. The loss can be justified on the grounds of the power of abstraction to make generalized comparisons across organizations, but you should not forget what you give up in the bargain.

As you focus on the interesting details that appear at the unit or task levels of analysis you will probably want to combine several different types from among the typologies. By encouraging you to think multi-dimensionally this technique will both stretch your imagination and strengthen your ability to perform modernist technology analysis. But remember to take great care with levels of analysis; it is easy to switch levels without being aware that you are doing so. Level switching is often illuminating but if you lose your bearings it will be hard to avoid confusion.

Technology in the symbolic perspective

Symbolically inclined organization theorists believe that, like every other aspect of organizations, technology is socially constructed. Thus technology does not only refer to physical objects like raw materials and equipment, but also to symbols including words, images, and metaphors. It is not just focused on task activities, but also on interactions between people and technology, and interpretation becomes as important as knowledge in understanding technology.

New (computer-based) technologies

In her 1988 book *In the Age of the Smart Machine* Shoshona Zuboff analyzed what at the time were called new technologies, a category referring to computer-based technologies such as those found in microelectronics, satellite communications, lasers, expert systems, robotics, and multi-media. She characterized the use of new technologies as requiring more interpretive processes than do traditional technologies, because processes involving computers involve manipulating symbolic representations (information or data) rather than tangible objects.

Karl Weick's theory of new technology derives from his examination of the role cognition, particularly interpretation, plays. Computer-mediated technology, typical of continuous production processes but also found in less complex technologies, allows operators to monitor production processes without ever touching, or in some cases even seeing, the product. What operators are able to know about what is happening inside computer-mediated processes is based on interpretations of symbolic representations provided as computer output (often in the form of numeric or graphic displays), and this information may or may not align with what is actually taking place out of sight. Weick characterized the ways new technologies differ from the technologies identified by Woodward, Thompson, and Perrow, in terms of their being stochastic, continuous, and abstract.[4]

Stochastic events are unexpected interruptions. While older technologies also occasion stochastic events (e.g., boilers sometimes blow up for no apparent reason), operators of new technologies experience these interruptions much more often. But the frequency with which stochastic events take place does not necessarily lead to learning, because each of these events is the unique product of dense interactions among the parts of a complex system. Thus the **stochastic** nature of new technologies means that their processes and underlying causes and effects cannot be well understood by their operators.

New technologies are often operated nonstop, which is to say they are **continuous** processes, but in ways never anticipated by Woodward, Thompson, or Perrow. One feature of computer work is the constant need for the revision and updating of both hardware and software. Computer technicians and programmers working with a continuous technology must change that technology while it is in operation. For example, in order to make flight reservations 24 hours a day, 7 days a week, 52 weeks a year, airlines must process data continuously; if the data processing system were to stop, even for short periods, chaos could ensue resulting in double bookings or the reporting of inaccurate flight times or incorrect destinations. Their continuous nature pushes new technologies to a much higher level of complexity compared to those described by Woodward, Thompson, and Perrow.

Compared to old technologies where you can see the moving parts of a machine or shadow a service provider, the working processes of computer-mediated technology are **abstract** and often hidden from view inside computers and other machines. Understanding new technologies therefore presents an operator with a highly abstract model that is once or twice removed from what the technical process is doing. Differences arising between the two processes—one in the head, the other in the computer—can lead to misunderstanding, error, and the possibility of conflicting interpretations of what things mean when a malfunction occurs. This has always been a problem for those who work with computers. Because a computer's hardware is operated via software that can never map the hardware's processes completely, there is always room for error and misunderstanding of what the underlying process is doing.

The stochastic, continuous and abstract qualities of new technology add a new level of complication to technology that makes them qualitatively different from even the most complex technologies described by Woodward, Thompson, and Perrow. Weick's theory thus complements dimensions of technology like non-routineness, standardization, and technical complexity. One implication of the stochastic, continuous, and abstract nature of new technologies is that they make **reliability** a big issue, which brings with it questions about how best to organize for high reliability. The importance of high reliability when using new technologies is perhaps most evident when applications of new technology involve dangerous activities, such as nuclear power production or air traffic control.

Perrow studied the dangers of new technology in his 1984 book *Normal Accidents*, an empirical exploration of technological failures such as the 1979 partial core meltdown of the nuclear reactor at Three Mile Island in the US. In it Perrow defined the failures of new technology he observed as impossible to anticipate, unique, and random. He explained their unpredictable behavior and the inability to analyze their failures as the result of an interaction between technical complexity and tight coupling. In Perrow's theory system **complexity** produces unexpected interactions between components, while **tight coupling** between those components involving human reactions to the unexpected system interactions means that the conditions ripe for failure escalate rapidly. The inevitability of the consequences of complexity interacting with tight coupling that Perrow saw in new technology prompted him to call their failures normal accidents.

In his analysis of the partial meltdown of the nuclear reactor at Three Mile Island, Perrow argued that the simultaneous failure of two fairly minor safety devices embedded in a complex, tightly-coupled system misled those involved in their attempts to intervene. According to Perrow, the dense interactions between components of the complex technical systems controlling the plant made it impossible to deduce the cause of the problem, and there followed a series of inappropriate interventions that created a series of further mechanical failures that increased the confusion of the operators. Mechanical failure interacting with human limitations escalated to the point of near disaster.

Perrow's morose conclusion was that prevention of normal accidents is unlikely because we will never be able to understand the underlying interaction effects of complexity and tight coupling well enough or fast enough to intervene effectively. That failures such as the 1986 meltdown at the Chernobyl nuclear facility in Ukraine and the 2010 oil spill in the Gulf of Mexico continue to plague us does little to disconfirm Perrow's view. However, Perrow does caution us not to overextend his theory by applying it to human moral failure, which is how he assessed the 2008 global financial crisis.[5] Bankers claiming not to have understood the complex interactions of tightly coupled financial instruments, in his view, paper over the real cause of the crisis—unrestrained human greed.

The social construction of technology

Though Weick and Perrow move into symbolic territory by giving interpretation a role in technology, their theories still harbor objectivity in that they define dimensions and variables with which to objectively test the explanatory power of their theories. Moving further into the realm of social construction theory requires seeing how non-technical concerns such as cultural norms and expectations shape technology. In contrast to how technology is portrayed in the modern perspective, social constructionists view technology, not as a pure application of science to productive work, but rather as the product of social, cultural, and economic factors in the environment.

The theory of the **social construction of technology** (SCOT) promoted by Dutch professor of science and technology Wiebe Bijker in collaboration with British sociologists John Law and Trevor Pinch, among others, describes how technologies are shaped by complex socio-cultural trade-offs.[6] Bijker and Pinch, for example, proposed an evolutionary model of technological innovation that exposed the role of social construction in the development of bicycling technology. According to their model technological innovation introduces variation to a population of products, following which users select those to be retained and those abandoned, thereby influencing which technologies will be selected from those on offer.

To demonstrate their theory they traced technological innovations in the bicycle industry. At one crucial point in bicycle innovation history that occurred in the early 1900s, they discovered that women cyclists who wore long dresses demanded certain modifications to the bicycle frame. Response to their demands produced a type of bicycle that was unappreciated by other users whose demands for stability and speed were met by competitive models, thus presenting the market for bicycles with considerable variation.

According to Bijker and Pinch, the bicycle we use today represents the evolutionary success of one of those technologies but their analysis revealed that social rather than purely scientific forces shaped the selection process. Moreover, the selected bicycling technology then influenced society and culture by helping to change attitudes toward women wearing trousers. In other words, strong preferences for speedier bicycles led to favoring one technology over others, but having established itself, the favored technology influenced society and culture to reduce the negative impact on women.

While a number of SCOT theorists focus on the macro level of technological innovation, as Bijker and his colleagues did, others examine interpretive processes that influence technological developments at the organizational or unit levels of analysis. Julian Orr's ethnographic study of the work of photocopier repair technicians at Xerox provides an example.[7] In order to explore how meaning is negotiated around technology, Orr, a researcher at the Xerox Palo Alto Research Center (now PARC), immersed himself in a community of Xerox photocopier repair technicians. He and the technicians attended classes at repair school, hung out at lunch, and went on service visits; all the while Orr audio taped their interactions and kept field notes. He also studied customers/users, their organizations, and the copy machines they used.

Orr concluded from his study that copy machines have both a technical and a social presence. Their technical presence—which is built into the machines—is constituted by mechanical and electronic technologies that require specific behavioral responses from their technicians and users. However, individual machines also have their own histories and ways of behaving, for example, some have a history of breakdowns, others make unique noises. This means that users and technicians often become attuned to the way they experience a particular machine and, even though they have an operating manual, they may need to improvise when interacting with these machines.

Orr discovered the social aspect of technology by observing conversations about copiers. For example, he observed technicians and customers negotiating the meaning of technical problems and the appropriate use of the technology the machines offered. Furthermore, Orr noted that technicians discussed their work among themselves, sharing knowledge and constructing their identities as competent technicians by showing off their skill in handling problems and carrying out successful repairs. Their regularized interactions resulted in the development of a community of practice and formed a subculture within Xerox. Thus Orr's study not only highlighted the socially constructed and situated nature of technical work and technology but also affirmed that the concepts of technology, social structure, and organizational culture influence each other.

You should recognize that the socially constructed nature of technology may be hidden from its users. Although much of the face-to-face collaboration Orr studied took place in the work setting, employees believed that most of their communication was mediated by their computers.[8] All employees at Xerox were linked through an intranet and everything they emailed to one another was documented by computer programs. However, much of the sharing and interpretation of information concerning work improvements and problem solving took place in their informal, spontaneous face-to-face gatherings.

Orr's findings indicate that managing technology (old or new) is not just about the technology itself, but also about the interactions and interpretations made by people using the technology. Furthermore those involved may be unaware of the interpretations they make or their consequences, raising concerns about technology that the critical postmodern perspective explores.

Postmodernism and technology

Postmodernists interested in a critical approach to technology trace their concerns about its abusive potential to German philosopher Martin Heidegger, an existential phenomenologist whose work falls within the symbolic perspective, as does his claim that the essence of technology lies in the manner in which it is used (particularly how we unlock its potential) and how we allow it to shape who we are.[9] However, in *The Question Concerning Technology*, Heidegger raised provocative questions about the relationship between technology and the self that resonate with the critical postmodern perspective. Much as Weber warned us that bureaucracy can become an iron cage, Heidegger saw grave danger in technology because, while it offers many seductions, it can also imprison us if we allow ourselves to become subservient to its needs.[10]

Following Heidegger's lead, postmodern organization theorists have studied how technology controls behavior by disciplining organizational members, and how managers gain power by controlling these technologies. Notice that, as we move into the postmodern perspective, there is a subtle shift in the use of the concept of technology. The linguistic turn of postmodernism is in evidence as the controlling practices of those who manage are turned into technologies of control by postmodern critics who want to reveal how technology affects the humans it serves.

Technologies of control and representation

Because technological design builds behavioral demands directly into production systems, managers and designers can exercise control over workers through the technologies they impose. Technologies discipline workers who must conform to their physical and often mental and emotional demands in order to perform their jobs.

Even more unsettling may be the perniciously seductive nature of technology that can cause us to lose our grip on what is real and imprison us in illusion. For example, while most postmodernists portray technology as a form of overt control, others comment on its ability to addict us to mass consumption or other aspects of modern ways of living. Consider how many people are bombarded daily by media and Internet images selling lifestyles and identities they are encouraged to consume and then communicate to others, enticing them to do the same. It is not much of a leap of imagination to move from here to the cinematic nightmare of technologically imprisoned lives portrayed by futuristic films like *Blade Runner*, *Minority Report*, and *The Matrix*.

In *The Postmodern Condition* Lyotard offered an explanation of how the technology of post-industrial capitalism has shifted social values away from truth and justice toward efficiency and rationality. The value for optimal performance achieved by minimizing energy expended while maximizing output is often enacted, he claimed, by decisions about the value of a person, department, or institution that are based primarily on their contribution to efficiency. Because character traits such as integrity and fairness are not clearly related to efficiency, the social values of truth and justice are neglected. The efficiency logic is often bolstered by the institutional myth that efficiency serves rationality. Once these ideas take hold, the more efficient and rational seeming the organization, technology, or person, the more power they acquire, but also the more firmly the system that defines power in terms of efficiency and rationality imprisons them.

Defining the terms by which power is bestowed leads us from consideration of technologies of control to an interest in the technologies of representation. If the way in which success, fame, celebrity, and other versions of power are defined marks out the road to their achievement, then representation itself becomes a technology for manipulating power and exercising control over others. It was in this sense that British organizational theorists Rod Coombs, David Knights, and Hugh Willmott equated information technology (IT) with managerial control.[11]

Coombs, Knights, and Willmott argued that IT is a means to direct thought and action in organizations and to discipline members for noncompliance with the desires or expectations of managers. They argued that the seeming objectivity of performance data conceals the fact that the categories into which data are collected and from which they are reported impose values on those who work within the system. For example, being forced to report the number of patients served per day in a hospital subtly reinforces a value for speedy processing, often at the expense of the value for quality care. Doctors, nurses, and administrators who feel pressured by the desire to keep their jobs and their self-esteem also feel pressure to buy into the speedy processing of patients.

The critical view recognizes that employees are not powerless within this system; they can resist control via sabotage (e.g., entering false data into the information system), non-responsiveness (e.g., refusing to react to feedback from the system), or joking (e.g., as a psychological defense against changing their values). However, the critique emphasizes the alignment between most modern technology theories and the interests of management. It was in this latter sense that Lyotard predicted that in the future the only knowledge valued will be that which can be translated into information for analysis and dissemination by computers. Power struggles will occur, not over the control of geopolitical territory as in the past, but over the control of information.

Lyotard ends *The Postmodern Condition* by predicting that the computerization of society will either lead to totalitarian control of the market system and the production of knowledge, or to greater justice. He warned that the path to greater justice only opens with free public access to information, as illustrated by the open source movement in computing that demands open access to the source codes from which computing applications are built. The movement alters technology at all levels from reorganization of computing and software industries, to enactment of specific open source applications such as the Linux operating system, and the Mozilla Firefox and Google Chromium web browsers.

Today we can do just about anything through virtual exchanges conducted over the Internet without any direct contact between us. The terror this future brings with it can be anticipated in the growth of cyberveillance—computer programs that can track every keystroke you make, every website you access, and that can hack your online accounts in order to capture your identity and security codes. Postmodernists acknowledge, however, that computer technology also encourages democracy and is a useful tool of economic, environmental, and political resistance. Social movements can provide information to mobilize and organize people across the globe.

Cyborganization

Technologies of representation can be employed to make organizations and actions appear to be real when they are not. Symbols and images have the power to produce a simulacrum, for example as is done by computer games involving three-dimensional virtual realities and other sensory experiences. Because they give users the illusion of having an objective experience, they can claim to invent a reality detached from objective existence. Postmodernists fascinated by the idea of 'cyborganizations' make a less radical break with reality that still subscribes to futurist visions of human dependence on technology. The points of contact between humans and machines are emphasized by the idea of the cyborg popularized in science fiction films like *Robocop* and *The Terminator*.

The term cyborg was coined by Manfred Clynes, a space scientist who researched ways to free astronauts from routine maintenance tasks in space, but it was American feminist Donna Haraway who wrote about cyborgs in a way that caught the attention of organization theorists. Haraway proposed using the cyborg myth, in the postmodern sense of a hybrid—something at once human and machine, simultaneously natural and artificial, mind and body, male and female, in other words a complete postmodern denial of all dichotomizing polarities.

In *Simians, Cyborgs, and Women: The Reinvention of Nature*, Haraway defined cyborgs as 'a kind of disassembled and reassembled, postmodern collective and personal self.'[12] She claimed that, by being embodied in one technologically enhanced creature, dualisms break down permitting old, stale social–political standoffs to be reconfigured. In this way Haraway applied cyborg imagery to the exploration of alternative realities to encourage embracing contradiction, deconstructing boundaries, and opening new connections—all of which mark the positive contributions made by the postmodern perspective and in particular the role that feminist techno-science plays in specifying the positive implications of high-tech culture for humankind.

According to British organization theorists Martin Parker and Robert Cooper, cyborganization, a contraction of cybernetic and organization, brings Haraway's cyborg myth into organization theory. Cybernetics is a branch of systems theory that focuses on communication and control in humans and machines. It contributes to organization theory when it defines patterns of information or activity as organization. One of the primary contributions of cybernetics has been its insistence on viewing organization as the outcome of bipolar forces of stability/instability and order/disorder. Cyberneticists not only acknowledge the complexity of bipolarity, they introduce the notion of complicity such as occurs when humans partner with machines in man–machine hybrids, which of course are cyborgs.

Cooper related Haraway's cyborg myth to developments in information theory suggested by American mathematician Norbert Weiner. According to Weiner: 'A piece of information, in order to contribute to the general information of a community, must say something substantially different from the community's previous stock of information.'[13] The implication of Weiner's insight, according to Cooper, is that information systems, which postmodern organizations increasingly are, thrive on their openness to novelty and surprise.[14]

If we are to appreciate cyborganizations, it becomes clear that we must see organizations as bound to their technologies, not just in their core production processes but through and through. Think of all the computers, video equipment, photocopiers, communication and transportation devices, manufacturing gear, and so on that make up most organizations. In these terms, can you think of any organization today that is not a cyborganization?

Actor network theory

The modernist view of scientific knowledge as the product of explaining, hypothesizing, and experimentation, is upended by actor network theory (ANT), which instead regards scientific knowledge as a social construction and understands scientific work as constructing data, composing texts, and negotiating with other scientists. Knowledge from the ANT theorist's perspective is a product of actor networks that organize various interacting materials (machines, people, buildings, concepts, written documents). This view of science, contributed by Michel Callon and Bruno Latour among others, was based on ethnographic studies of science in action.[15]

In their influential studies both Latour and Collon observed that actors never act alone but always in conjunction with things, for example scientists conduct science with petri dishes and telescopes. Consequently actor network theorists place actors within a network of other actants, a term borrowed from French semiotician Algirdas Julien Greimas to embrace both those who act and that which is acted upon, including humans and non-humans. In ANT any act carried out implies a network of interacting actants as driving a car requires a driver, the car, a road, driving regulations, a license, and so forth. The term actor-network arises from the belief that it is the network, not the actor alone, that performs an act, whether this be an act of science, technology, organization, or any other socio-material phenomenon.

In a key study that laid the groundwork for ANT, Latour spent two years doing an ethnographic study of how research was conducted at the Salk Institute for Biological Studies in California. In his words, by focusing on how science is conducted, he: 'was trying to account for the various ways in which truth is built.'[16] In 1979 Latour and British sociologist Steve Woolgar presented the Salk study, in *Laboratory Life: The Social Construction of Scientific Facts*, in which they concluded that what Latour had observed involved a lot more power and politics than was normally acknowledged within the scientific community.

The book provoked considerable controversy, not only because it claimed that scientific work is socially constructed from a 'seething mass of alternative interpretations' and from 'the confrontation and negotiation of utter confusion,' but also because practitioners of normal science expected research focused on science to be conducted using objective scientific methods, not qualitative ethnography borrowed from the social sciences. Even more unsettling for some, ANT employed postmodernism's tactic of decentering the subject. By defining societies, technologies, and organizations as effects of the interacting heterogeneous materials circulating within them, ANT had made humans just another element in the network, neither more nor less important than any other.

ANT depends upon two main assumptions. First, the social world is materially heterogeneous, in other words, buildings, machines, actors' bodies, written documents, other physical objects, and talk are all involved in the process of socio-technical ordering, which includes making sense of, constructing, and maintaining the network. Second, the elements of an actor network only achieve meaning and identity in relation to other elements, they do not have a fixed existence independent of these relationships. Known in ANT as the principle of relationality, this idea resonates strongly with the linguistic ontology of postmodernism, with the main difference being that ANT leans more heavily on materiality, at least that of some network elements.

Based on these assumptions, organization theorists use ANT to study organizations as networks of relationship between human and nonhuman actants (technical, physical, natural, body, thought, text, etc.). The human actor is no more or less important than any other material, but acts as the translator who builds coherence and organization from all the bits and pieces. Network objects are fluid and many of the ways that network materials adapt to particular circumstances are invisible.[17]

Take the example of a company manufacturing high-pressure mercury lamps used for street lighting. Decreased demand for mercury lamps and growing demand for the higher quality, more efficient natural light provided by metal halide lamps convince production and design engineers to modify their company's existing machine so that it will produce the new type of lamp. The physical shape and design of the machine, its components, raw material inputs, operating procedures, operator behavior, problem-solving activities and interactions, quality standards, and so on will change as these elements of the network interact and try to organize and adapt themselves to the demands of manufacturing and supplying the new product.

ANT competes with the related ideas of social construction of technology (SCOT) and social network theory. Whereas SCOT presents technology and people as interacting but separate entities, in the ANT perspective as stated by Latour: 'Society and technology are not two ontologically distinct entities but more like phases of the same essential action.'[18] In ANT technology achieves meaning and thereby exists because of relationality (between people, work, artifacts, and so on) and therefore it must be studied and managed as an integral part of the actor network. Similar to social network theory, ANT focuses on the relationships between elements in the network rather than on the elements themselves, but unlike social network theory, ANT theorists adopt the assumptions of interpretive epistemology presumed by their ethnographic methods. Additionally, decentering human actors satisfies one of the conditions of postmodernism.

Combining technology, social structure, and environment

Advocates of the normative approach to technology want to know how the use of new technologies, such as social media, affect the way an organization should be designed and managed. Modernist organization theorists who have examined the relationship of new technology to social structure claim that computer technologies and communication networks have made classical organizational and work designs obsolete. For example, new technologies reduce the need for physical proximity, hierarchical controls, and the face-to-face mechanisms of integration (e.g., supervision, liaison roles, co-located teams), and have enabled the work of virtual organizations and other co-acting groups.

New technologies can also lead to greater decentralization of decision making because data are more readily available—integration occurs through electronic linking, increased spans of control, and decreased hierarchical levels. Software programs correct errors and make the exchange of greater amounts of information easier and faster.[19] But examining changes in the relationships between social structure, technology, and the environment demands that we understand their historical patterns.

In this final section I will review some important history concerning changing ideas about the role of technology and its relationship to structure and environment, starting with the story of how Woodward brought technology into organization theory and thereby helped to found contingency theory.

The technological imperative

Woodward's influential study ushered in the idea that technology determines which sort of organizational structure is most effective. Belief in this idea came to be known as the **technological imperative**—that is, choosing a technology determines the preferred organizational structure. That technology could predict the success of a given structure would lead others to formulate contingency theory, but meanwhile organization theorists intent on replicating and extending Woodward's research, found evidence that undermined belief in the technological imperative.

One set of scholars known as the Aston Group, because they worked at Aston University in the UK, presented empirical evidence that the influence of technology on structure depends on the size of the organization; the smaller the organization the greater the significance of technology for the structure–performance relationship.[20] The Aston researchers explained that when organizations consist of little beyond their core technology, as was the case for the relatively small organizations studied by Woodward, then technology has a significant and possibly determining effect on social structure. But as organizations become more complex this relationship disappears.

Another way to interpret the Aston studies is to recognize that social structures relate to all the technologies in use, which for some units and their employees will not be the core technology of the organization, but the technology of their unit. In small organizations most employees are directly involved with the core technology, for example, a small welding company will employ mainly welders with perhaps one staff person. In large organizations many employees rely on technologies that are not directly related to the core. Thus, the overall characteristics of social structures in larger organizations reflect the greater differentiation and integration of a wider array of technologies than do social structures in small organizations. This means that in large organizations the relationship between the core technology and the general characteristics of the complex social structure that organizes all the different units with their different technologies will be harder to determine. Technology and structure are still significantly related, but the relationship is vastly more complicated in large organizations than it is in small ones.

Technical complexity, uncertainty, and routineness

You will recall that Woodward distinguished technologies by their technical complexity, measuring this variable as the extent to which machines perform core transformation processes. In relating technical complexity to structural arrangements, Woodward noticed that technologies at both extremes of her scale (unit and continuous processing technologies) were best served by organic structures, while technologies in the middle range (large batch, mass production) performed better with a mechanistic structure.

Woodward explained this pattern using the concept of the **routineness of work** involved in different types of technology. Woodward noticed that both unit and continuous processing technologies involved work that was non-routine relative to the work associated with mass production, which was routine. Unit and continuous process technologies are therefore better suited to organic structures, she reasoned, because they are more compatible with non-routine work. On the other hand, she predicted that mass production technologies would be better suited to mechanistic structures because these structures encourage and support routine work.

It may help you to remember the relationship Woodward discovered between the routineness of work and technical complexity if you picture the inverted U-shaped curve shown in Figure 5.5. Consider, for example, a graphic art firm that serves clients by designing logos and producing finished artwork for use in magazines and on websites (a unit/small batch technology having low technical complexity but requiring fairly non-routine work). Compare this organization with a manufacturer of standardized electrical components whose raw materials and manufacturing processes vary little across time (a mass production/large batch technology with high routineness of work and moderate complexity). Now compare both of these to a nuclear power plant where most of the work done by humans consists of monitoring machines (a continuous processing technology with high technical complexity and low routineness due to the non-routine nature of work when problems arise).

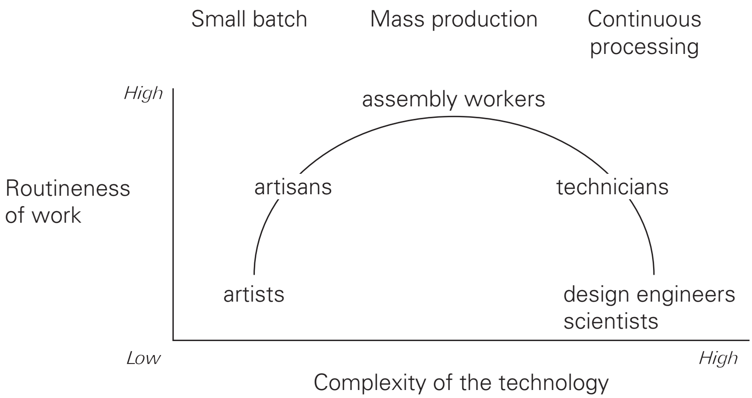

Figure 5.5 The relationship between routineness of work and technical complexity

Woodward's findings indicated that both unit and continuous processing technologies are associated with low routineness, while mass production technologies have high routineness; thus the relationship between routineness of work and technical complexity takes the inverted U shown in this figure.

The graphics design firm needs to be much more responsive to client needs and flexible in relation to how work is accomplished than does the manufacturing company. And although most work in a nuclear power plant is highly routine, when the equipment malfunctions workers must be ready for anything. For this reason they keep their structure flexible to allow them to confront the stochastic need for extremely non-routine activity.

Although Perrow categorized technologies on a different basis than did Woodward, he too noted the importance of routineness when he included routine and non-routine as two types of technology. Perrow refined Woodward's conceptualizations of the routineness of work, by breaking the dimension of routineness into the sub-dimensions of task variability and analyzability, which enhanced the predictability and accuracy of applications of technology theory to organizational design. Refining theoretical relationships like this grounds many developments within the modern perspective such as adding a new contingency to those already proposed.

For example, Perrow's interest in non-routineness led him to focus on technology as a determinant of uncertainty in organizations. According to Perrow, technology contributes to uncertainty either through variations in the quality or availability of inputs to the transformation process or through the variable nature of the transformation process itself. When uncertainty is high it becomes difficult to design a structure to support the activities of the organization because the activities that are required are not always known in advance.

Perrow's and Woodward's discussions of the effects of technology are like two sides of a single coin. Both explain the links between technology and social structure in terms of the routineness and non-routineness of work. However, whereas Woodward was the first to propose the relationship between technology and social structure, Perrow sought a more thorough explanation for it. Like Perrow, Thompson looked for deeper understanding of the links between technology and social structure, but in contrast to Perrow, did so with greater emphasis on social structure.

You can see the positivist drive to accumulate knowledge here—first Woodward discovered the importance of technology in understanding how organizational structure and performance are related, then Thompson added service technologies to extend the theory beyond manufacturing organizations, and finally Perrow elaborated the differences between technology types when they are viewed from the unit and task levels of analysis.

Task interdependence and mechanisms of coordination

Following Woodward and Perrow's emphasis on variability in the routineness of work, Thompson recognized that the work processes associated with a technology vary in the extent to which they are interrelated. He called this variable **task interdependence** to emphasize the issue of dependence on others for the accomplishment of tasks. Thompson related the task interdependence created by technology to different possible coordination mechanisms that could be designed into an organization's social structure. His work on task interdependence identified links between different forms of coordination and the mediating, long-linked, and intensive technologies framed by his typology.

In a mediating technology a number of offices or officials perform their work tasks almost independently of one another, at least so far as actual work flows between units is concerned. Therefore, little direct contact is needed between units (or individuals). Thompson used the term **pooled task interdependence** to refer to cases in which the output of the organization is primarily the sum of the efforts of each unit (see Figure 5.6).

Take banking as a prime example of mediating technology. Banks mediate between borrowers and savers or investors, and their mediation can be accomplished simultaneously by several bank branches that operate almost independently of one another. Day and night shifts on an assembly line, franchised restaurants, and the different departments of a university, or a large retail store provide additional examples of organizational units whose work is typified by pooled task interdependence.

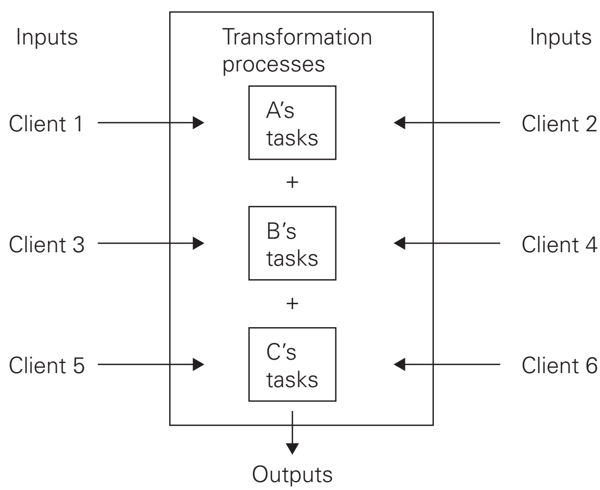

Figure 5.6 Mediating technologies generate pooled task interdependence

Notice that A, B, and C's joint product forms the output of the organization, yet these three units can operate more or less independently of one another.

According to Thompson, groups operating with pooled task interdependence demand very little in the way of coordination. The coordination required to achieve a coherent organizational identity or to ensure that services are consistent across units can, for the most part, be accomplished through the use of **rules and standard procedures** for routine operations. For example, rules and standard procedures for tasks such as opening bank accounts, investing in certificates of deposit or mutual funds, and applying for and approving loans and lines of credit produce sufficient coordination for a bank to integrate the activities of its branches.

Long-linked technology involves both pooled and sequential task interdependence. For instance, several assembly lines can operate at once in a manner that leaves them practically independent of one another; in this regard the different lines are pooled in the sense that their outputs are aggregated into the total output of the organization. However, within each line interdependence is more complex because each worker is dependent on the work of others located at positions prior to theirs on the line. If workers early in the process are not performing their tasks properly, then the work of those further down the line suffers. This is called **sequential task interdependence** because the work tasks are performed in a fixed sequence (Figure 5.7).

The sequential nature of task interdependence found in long-linked technologies requires more **planning and scheduling** than does pooled interdependence. Again consider the assembly line as an example. All work tasks must be designed and workers assigned and scheduled to work together in order for the assembly line operation to function properly. Because any break in the line can interrupt production, careful planning of tasks and scheduling of workers is imperative. Of course, in addition to coordination by plans and schedules, rules about coming to work on time and procedures to follow when something on the line has created a problem are also part of coordinating this type of technology.

The scope of the task within an intensive technology is too large for one individual to perform the transformation alone, so there is need for an exchange of information between workers during the performance of their tasks. Thompson describes this as **reciprocal task interdependence**. In a restaurant, for example, the kitchen staff and the wait staff have reciprocal interdependence because the kitchen is dependent upon the wait staff to provide orders, and the wait staff is dependent upon the kitchen staff to provide meals prepared to the customers' satisfaction. The primary difference between sequential and reciprocal task interdependence is that, where long-linked technologies involve work flows that move in one direction only, intensive technologies involve reciprocal work flows (see Figure 5.8).

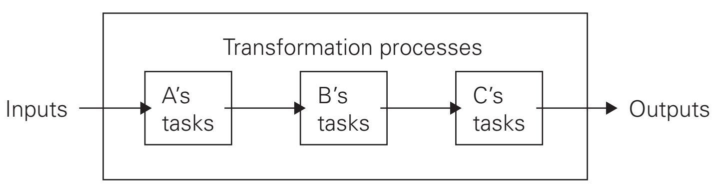

Figure 5.7 Long-linked technologies are associated with sequential task interdependence

This type of technology generates an unbalanced relationship where A experiences the least dependence and C the most, with B's dependence being less than C's but more than A's.

Coordinating the tasks central to the operation of an intensive technology requires **mutual adjustment** on the part of the individuals or units involved due to the reciprocal nature of their task interdependence. When intensive technologies involve immediate reciprocal coordination, mutual adjustment takes the extreme form of teamwork. In teamwork, work inputs to the transformation process are acted upon simultaneously by members of the work team, rather than passing inputs back and forth as is the case for less intensive forms of reciprocal task interdependence.

Take the case of an emergency room surgical operation. A surgeon needs to be able to continuously exchange information with the anesthesiologist, assisting doctors, and nurses during the performance of the operation. Thus, intensive technologies require joint decision making and either physical co-location or a direct channel of communication such as a satellite link or other instantaneous communication device.

Be sure to notice that intensive technology also involves pooled and sequential task interdependence. Mutual adjustment, planning, scheduling, rules, and procedures all contribute to the ability of experts to perform when and where their services are required. For example, emergency room doctors have scheduled work hours and rules to follow, ranging from established surgical procedures to wearing a beeper when they are on call. Notice how, as task interdependence increases from pooled to sequential to reciprocal, mechanisms of coordination get added to the organization (see Table 5.2). Pooled interdependence only requires rules and procedures, but sequential interdependence uses rules, procedures, and

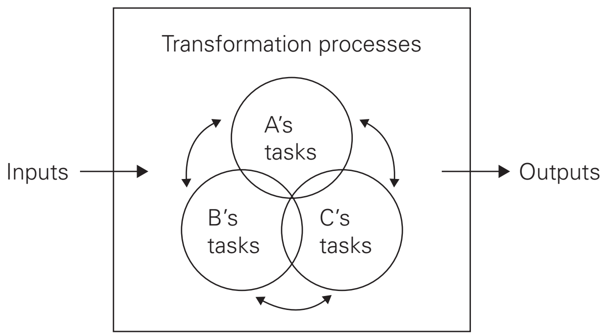

Figure 5.8 Intensive technologies create reciprocal task interdependence

A, B, and C are mutually dependent; thus this type of technology generates the highest levels of task interdependence.

Table 5.2 As task interdependence increases, increasingly sophisticated coordination mechanisms will be added to those already in use by an organization

Task interdependence	Rules and procedures	Schedules and plans	Mutual adjustment
Pooled	x		
Sequential	x	x	
Reciprocal	x	x	x

Source: Based on Thompson (1967).

scheduling, while reciprocal interdependence uses all these forms of coordination plus mutual adjustment.

Information processing and new technologies

Jay Galbraith, an American organization theorist, proposed that complexity, uncertainty, and interdependence place demands on an organization to process information in order to coordinate activities.[21] Galbraith claimed that it is demands for **communication** that shape the structure of the organization. He argued that technical complexity leads to structural complexity, uncertainty promotes organic forms, and interdependence increases demands for coordination *because* these factors increase the communication load carried by an organization. It is the communication load, however, that directly affects how people interact and thus the organization's social structure.

According to Galbraith, the effects of technology and the environment on social structure are mediated by communication. Notice the similarity between Galbraith's and Woodward's theories. Just as Woodward identified technology as a mediating factor in the structure–performance relationship, Galbraith argued that communication mediates the relationships between technology and structure, and environment and structure. This progressive elaboration and refinement of distinctions and relationships is another way modernist organization theorists develop new contingency theories.

Perrow's elaboration of the routineness of work scale, his addition of uncertainty as a response to technology, and Galbraith's proposal that communication mediates the relationship between technology and social structure all led to developments within contingency theory. But the shackles of contingency thinking would be broken for the first time when symbolism came into view, and one of the first efforts to bring modern and symbolic perspectives together, Giddens's structuration theory, proved inspiring to organization theorists interested in technology.

Technology and structuration

Many critical postmodernists believe that the material properties of technology force us to behave in ways predetermined by the equipment technology provides, for example the physical components of a computer force us to sit in front of a screen for hours on end. Because technology similarly programs interactions among workers, they conceptualize social structure as embedded in technology. Others, adopting SCOT or ANT, believe that social structures and technology emerge *from* those interactions. For example, the mobile and yet interconnected lives that caused computer technology to adapt, taking the form of laptops, tablets, and smartphones move collaboration and teamwork toward the virtual.

Accepting both these points of view, **adaptive structuration theory** proposed examining **technology-in-use**.[22] Adopting this approach, American organization theorist Wanda Orlikowski found that individuals often use technology quite differently. Graphic artists and accountants, for example, use different software programs; and some people type with two fingers while others use all ten. Orlikowski argued that individual usage constitutes differences in what objectively might seem like the same technologies as they identify and use different features, develop their own style of interacting with technology, and base their sensemaking on technologically mediated data. Thus humans give meaning and shape to technology as it shapes them through the mediation of practices.[23]

A technology-in-use may be resistant to change as we develop habits and then attribute them to the system, but it may change as we modify the technology or improvise new practices. In another study Orlikowski observed how different groups in a multinational consulting firm used a software program called Notes. She found that technology staff used Notes extensively and often customized it to their own needs. Routines they enacted around the Notes technology included electronic discussions, information sharing, and cooperative troubleshooting—a collaborative technology-in-use. However, most consultants used the software minimally, enacting a more limited version of the technology-in-use. These users had little knowledge about Notes and were skeptical about its value in helping them do their jobs. So, even though the technology was technically the same for both groups of users, practices varied across contexts depending upon the users' levels of interest and the practical, institutional, and interpretive limits of the technology they perceived.

According to the theory of technology-in-use, structure emerges from both the physical properties of technology and the ways we interact with and construct that technology. As Orlikowski put it: 'Technology is physically constructed by actors working in a given social context, and technology is socially constructed by actors through the different meaning they attach to it and the various features they emphasize and use.'[24] This can be seen across the field of information technology (IT) and in the practices of dotcoms and social media companies like Google and Facebook, where technology and social structure emerge as people improvise their use of technology while they produce the technologies still others will use. In these organizations, the product is not necessarily a concrete object, but may be a database, website or information-processing routine. In this technologically oriented application of structuration theory the methods of production are interwoven with the end product as people use the technology for their own purposes as well as those of the organization.

The global village: Technology and globalization

Concerns about unlimited and surreptitious control, or breaches of privacy and security, create images of the evils to which technology-in-use can lead, but technology also unleashes powerful forces to combat these negative effects by providing support for freedom and democracy. Postmodern theorists interested in the liberating potential of technology concentrate on understanding and enhancing its ability to transform the world. Some, for example, see new technology creating a global village tied together by strong social bonds that work even when large geographical or cultural distances separate people.[25]

Others believe that new technology and social media will play yet to be fully understood roles in social and cultural developments taking place around the world. Even though these developments are still underway, we know that new technology-enabled social media were used by those who enacted the Arab Awakening and by members of the Occupy movement to help them organize, lobby, and take collective action, sometimes reaching around the globe to find inspiration as well as social, technical, and financial support from like-minded others. It remains to be seen how the uses of new technology in combination with the ever-changing conditions and trends in the environment will affect the shapes and forms organization and organizing take on in the future.

Summary

From the modernist perspective, technology is typically defined in terms of its:

- Objects—products, services, and the tools and equipment used in their production.
- Task activities and processes—the methods of production.
- Knowledge needed to develop and apply equipment, tools, and methods to produce a product or service.

In organization theory the term technology refers not only to technologies that contribute directly to organizational output, but also to technologies that indirectly maintain this function (e.g., purchasing, sales, accounting, internal communication), and to technologies for adapting the organization to its environment (e.g., economic analysis, market research, strategic planning, external communication). To avoid confusion, organization theorists use the term **core technology** to mean the transformation processes by which the organization's products and services are produced. Large diversified organizations often have multiple core technologies, but every form of work has a technology that can be defined at the unit or task level. Thus, the modern perspective on technology describes the set of interacting and interdependent technologies on which an organization depends.

Although modernist theories give us an image of technology as lying inside organizational boundaries while environment stays outside, these two concerns are closely connected in the modernist perspective. First of all, the knowledge needed to operate a technology is normally produced outside the organization's boundary and imported, except when basic research is conducted internally, as is sometimes done in R&D departments. Second, tools and many production processes are imported in the form of hardware, software, and skilled or educated employees. The environment provides the technological ingredients of an organization just as it provides the material resources upon which the organization depends for its survival. Technology and other resources are scattered about in a more or less random fashion until a portion of the environment becomes organized, that is, until resources and technologies are combined by organizations to provide outputs to satisfy the environment's needs or demands.

A different image of technology is offered by the symbolic perspective. Drawing on subjectivist ontology suggests studying how technology is constructed and used within a socio-cultural context of symbolic interaction and meaning making. While some engage in ethnographic studies, those who believe in the social construction of technology (SCOT) often use historical analysis to build theory about how social, cultural, and economic contexts link resources and people to shape technological innovations. Both provide views of how the social organization of society influences the shape of technology and its products. This raises the question of how society, in its turn, is shaped by technology. The theme of society being shaped by technology is taken up in postmodern theories of technology, such as those that critique management systems as technologies of control, or present ideas like cyborganization and the global village.

Key terms

technology
- *core technology*

services
technical complexity
unit and small batch production
large batch or mass production
continuous processing
long-linked technology
mediating technology
intensive technology
task variability
task analyzability
routine technology
craft technology
engineering technology
non-routine technology
new (computer-based) technologies
- *stochastic*
- *continuous*
- *abstract*

reliability
normal accidents
complexity and tight-coupling
social construction of technology (SCOT)
technologies of control and representation
cyborganization
actor network theory (ANT)
technological imperative
routineness of work
task interdependence
- *pooled*
- *sequential*
- *reciprocal*

coordination mechanisms
- *rules and standard procedures*
- *planning and scheduling*
- *mutual adjustment*

communication
adaptive structuration theory
technology-in-use

Endnotes

1. See more about Nissan's Shift campaign and its relationship to corporate identity at: http://www.nissan-global.com/EN/COMPANY/SHIFT_/index.html (accessed February 18, 2012).
2. Thompson (1967).
3. Perrow (1967, 1986).
4. Weick (1990).
5. Perrow (2011).
6. Bijker, Hughes, and Pinch (1987); Bijker and Law (1992).
7. Orr (1996).
8. Mangrum, Fairley, and Weider (2001).

9. Heidegger (1993: 341).
10. In spite of the threat technology poses, Heidegger believed that the closer we come to the danger, the more likely we are to ask critical questions that will allow us to avoid disaster. Furthermore, by questioning its effects, we not only avoid the shackles of technology, but we open new horizons.
11. Combs, Knights, and Willmott (1992).
12. Haraway (1991: 163).
13. Weiner (1954), cited in Parker and Cooper (1998: 214).
14. Cooper and Law (1995: 268), cited in Parker and Cooper (1998: 219–20).
15. Collon (1986); Latour (2005); see also Law (1992).
16. Latour and Woolgar (1979: 36).
17. deLaet and Mol (2000); Law and Singleton (2003).
18. Latour (1991: 129).
19. Huber (1990); Lucas and Baroudi (1994).
20. Pugh et al. (1963).
21. Galbraith (1973).
22. DeSanctis and Poole (1994); Griffiths (1999).
23. Orlikowski (2000).
24. Orlikowski (1992: 406).
25. McLuhan and Powers (1989).

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